# OC4610 - WAVE AND SURF PREDICTION

LAB #1 – January 22, 2004

## I. INTRODUCTION/BACKGROUND

In this weeks lab students will be examining some wave data collected as part of the DUCK_94 experiment off the outer banks of North Carolina. The data in question consists of bottom mounted pressure records collected from July to December 1994 at each of 9 sites off Duck, NC in depths from 6 to 87 meters (Fig1, Table 1). Specifically, students will be working with data collected during Hurricane Gordon which reached its peak in the study area on November 18. The purpose of this lab is to investigate the evolution of the wave field at different sites during the hurricane. To do this the students will make some basic wave calculations from the pressure data from each site.

## II. DATA

The data were collected in self-contained pressure sensors mounted on the bottom. For this lab we will only look at data collected at sites B-H. Pressure data were collected at a sampling rate of 2 Hertz at sites C,D,F, and H, and at 1 Hertz at sites B,E,and G. Students will be responsible for examining the data from a single sensor and will examine 8 one hour segments of data spaced every six hours for a period of 48 hours around the peak of the storm (see Table 2).

The data for each pressure sensor are located in the directory **~jessen/oc4610/data**. The file naming convention is s9411DDHH_X.asc where DD is the day (17,18, or 19), HH is the hour (1,7,13, or 19) and X is the site designation (B,C,D,E, F,G, or H). Each file is an ascii file containing either 7200 (for the 2 Hz data) or 3600 (for the 1 Hz data) records. Each record contains information for a single data point. The record structure is as follows:

- Field 1 - Date in the form of YYMMDD where YY is the year, MM is the month, and DD is the day.
- Field 2 - Time in the form of HHMM where HH is the hour and MM is the minute.
- Field 3 - Decimal minutes.
- Field 4 - Pressure in cm.

## III. LAB TASKS/PROCEDURES

Each student is responsible for producing the following for this lab:
For each of the 8 data segments:

**1)** Calculate the mean water depth from the bottom pressure data,
**2)** Calculate/plot the bottom pressure spectra,

**3)** Calculate/plot the surface height spectra from the bottom pressure data, (put plots for 2 and 3 on the same panel to save paper),
**4)** Calculate the significant wave height, and
**5)** Determine the peak wave period.

Answer the following questions:
**1)** Describe how the surface height spectra evolves over the 48 hour study period.
**2)** How did the significant wave height Hs and the peak period of the waves change during the study period?

The significant wave height and the peak wave period should be written on the plot. Label each plot, clearly specify the time and site of each plot. Making a plot of the significant wave height and peak period may help in answering the above questions.

**SPECIFIC PROCEDURES**

The specific procedures needed to accomplish these task can be broken down as follows. It is suggested that you write a matlab mfile to accomplish steps 2-end:

**1)** Copy the appropriate data files from my directory into your working directory. From your working directory use the command:
**cp ~jessen/oc4610/data/*X.asc .** where X is the site designation for your site.

**2)** Load the data file into the matlab environment.

**3)** Extract the pressure data from the data file. For example, for the sensor at site B on Nov. 17 at 1300 the command **prs=s94111713_B(:,4)** would assign the pressure data from this sensor to the variable "prs".

**4)** Calculate the bottom pressure spectral density. The command: **[bps,f]=psd(prs,npts,hz,'mean')** returns the bottom pressure spectral density **(bps)** and the frequencies at which the spectrum is estimated **(f)** given the raw bottom pressure time series **(prs)**, the number of points per segment **(npts)**, and the sampling frequency **(hz)**. The extra parameter 'mean' indicates that the segment is to be detrended by removing the mean before performing the spectral calculations**. For 1 hz data use 128 points per segment and for 2 hz data use 256 points/segment.**

**5)** Once a bottom pressure spectrum has been calculated using the appropriate number of points, convert the power spectrum to a variance conserving spectrum by multiplying it by 2/hz: **bps2=bps*2/hz.**

**6)** The commonly used estimation of surface height spectral density is only valid up to a frequency of about 0.14 Hz. Therefore we will cutoff the bottom pressure spectrum at this frequency before estimating the surface height spectrum. Use the m-file **cutoff.m** in the ~jessen/oc4610/mfiles directory to accomplish this task. The command;

**[nf,nbps]=cutoff(f,bps2)** returns a new frequency array **(nf)** and bottom pressure spectrum **(nbps)** given the frequency array **(f)** and the bottom pressure spectrum **(bps2)** calculated in step 4.

**7)** Estimate the surface height spectral density. This can be estimated as the bottom pressure spectral density times cosh2(kh) where k is the wave number and h is the water depth. The wavenumber array can be calculated using the m-file function **wavenum2.m** located in the ~jessen/oc4610/mfiles directory. This function returns an array of wave numbers **(k)** when supplied with an array of frequencies **(nf)** and the water depth (in meters)**(h):**

**k=wavenum2(nf,h)**

Consider water depth to be the average pressure for each time series. You are now ready to calculate the surface height spectrum using the following:

**sfcspc=nbps.*cosh(k*h).^2**

(The ".*" and ".^" are scaler operators and must be used).

**8)** The significant wave height is defined as the average of the heights of the one-third highest waves in a series. It can be approximated as four times the square root of the surface height variance:

**swh=4*sqrt(sum(sfcspc)*delf)/100**

where **delf** is the difference between successive frequency values (i.e. frequency band 2 – frequency band 1).

**9)** Plot the bottom pressure and surface height spectra on a semilogy plot.

**<u>Other info:</u>**

Needed standard matlab routines:
psd,
semilogy
Needed special matlab m-files:
/home/a5/jessen/oc4610/mfiles/cutoff.m
/home/a5/jessen/oc4610/mfiles/wavenum2.m

The following segment of matlab code can be put at the beginning of your m-file to accomplish items 2 and 3 on the above list:

```
---
fle=input('Enter data file name: ','s');
data=load(fle);
prs=data(:,4);
---
```

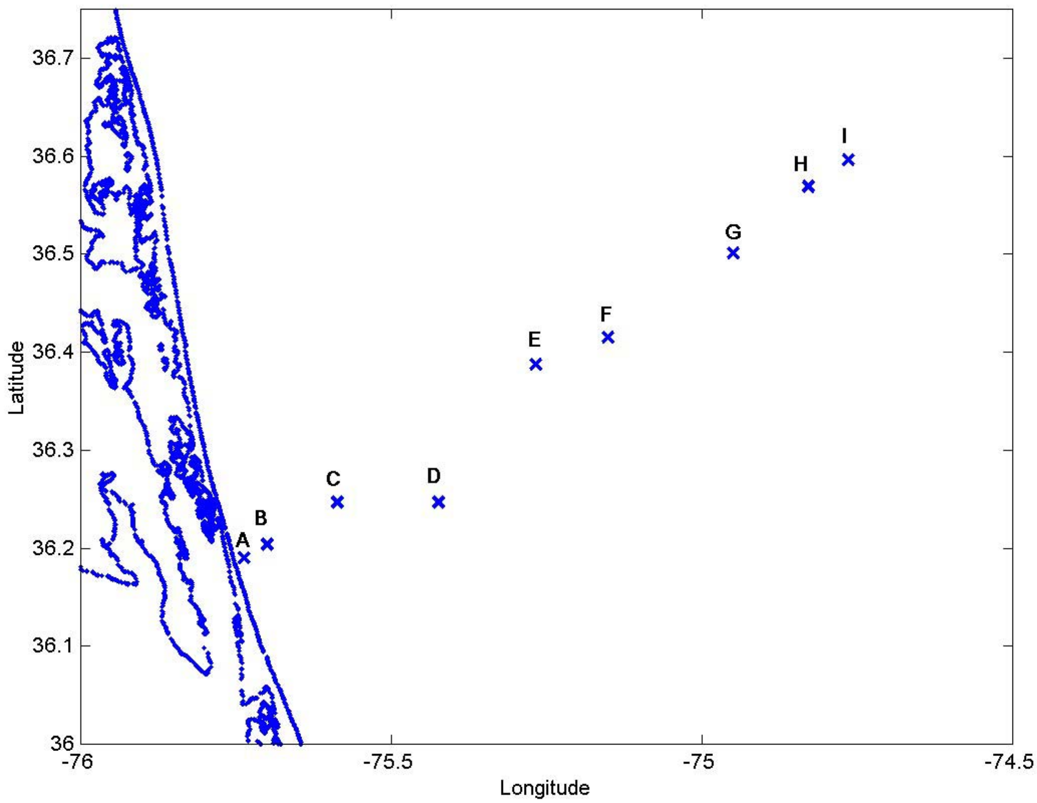


Figure 1 - Deployment positions for bottom mounted pressure sensors used during the DUCK94 experiment.

Table 1 - Site number, sensor number, depth, and position of sensors deployed during the DUCK_94 experiment and to be used in this lab.

| SITE | SENSOR | POSITION | DEPTH | SAMPLE RATE |
|---|---|---|---|---|
| B | 3 | 36° 12.24' -75° 41.98' | 20.0m | 1 Hz |
| C | 2 | 36° 14.81' -75° 35.18' | 25.0m | 2 Hz |
| D | 7 | 36° 14.82' -75° 25.46' | 34.0m | 2 Hz |
| E | 11 | 36° 23.25' -75° 16.05' | 34.0m | 1 Hz |
| F | 6 | 36° 24.90' -75° 9.08' | 31.5m | 2 Hz |
| G | 5 | 36° 30.07' -74° 56.97' | 45.0m | 1 Hz |
| H | 9 | 36° 34.16' -74° 49.74' | 49.0m | 2 Hz |

Table 2 - File naming convention and times associated with bottom pressure data files. Each file contains one hour of data.

| FILE | STARTING TIME |
|---|---|
| s94111713_X.asc | 11/17:1300 |
| s94111719_X.asc | 11/17:1900 |
| s94111801_X.asc | 11/18:0100 |
| s94111807_X.asc | 11/18:0700 (Approximate peak of storm) |
| s94111813_X.asc | 11/18:1300 |
| s94111819_X.asc | 11/18:1900 |
| s94111901_X.asc | 11/19:0100 |
| s94111907_X.asc | 11/19:0700 |

"X" is the site designation (B,C,D,E,F,G, or H)